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JADS JT&E

JADS Special Report on Programmatic Challenges to Distributed Testing

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Joint Advanced Distributed Simulation
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1.0 Introduction

The Joint Advanced Distributed Simulation Joint Test and Evaluation (JT&E) was chartered by the Deputy Director, Test, Systems Engineering and Evaluation (Test and Evaluation)[1], Office of the Secretary of Defense (OSD) (Acquisition and Technology) in October 1994 to investigate the utility of advanced distributed simulation[2] (ADS) technologies for support of developmental test and evaluation (DT&E) and operational test and evaluation (OT&E). The program is Air Force lead with Army and Navy participation and is scheduled to end in March 2000.

The JADS JT&E charter focuses on three issues: what is the present utility of ADS, including distributed interactive simulation (DIS), for test and evaluation (T&E); what are the critical constraints, concerns, and methodologies when using ADS for T&E; and what are the requirements that must be introduced into ADS systems if they are to support a more complete T&E capability in the future.

The JADS JT&E investigated ADS applications in three slices of the T&E spectrum: the System Integration Test (SIT) explored ADS support to air-to-air missile testing; the End to End (ETE) Test investigated ADS support to command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) testing; and the Electronic Warfare (EW) Test examined ADS support for EW testing. The JADS Joint Test Force (JTF) was also chartered to observe or participate at a modest level in ADS activities sponsored and conducted by other agencies in an effort to broaden conclusions developed in the three dedicated tests.

A key finding of the JADS JT&E was that the primary challenges to developing and executing a distributed test are programmatic rather than technical. The requirement to interact with multiple facilities and organizations with their associated processes presents potential problems over the full range of test planning from concept development to implementation. This special report is a companion report to the JADS report, *A Test Planning Methodology -- From Concept Development Through Test Execution.* The report mirrors the ADS-based test planning and implementation steps and provides insight into the challenges a program or test manager will encounter during each step. The report is formatted with extracts from *A Test Planning Methodology -- From Concept Development Through Test Execution* identified in italics.

[1] This office is now the Deputy Director, Developmental Test and Evaluation, Strategic and Tactical Systems.
[2] ADS is a networking method that permits the linking of constructive simulations (digital computer models), virtual simulations (man-in-the-loop or hardware-in-the-loop simulators), and live players located at distributed locations into a single environment/scenario. Such linking can result in a more realistic, safer, and/or more detailed evaluation of the system under test.
[3] ADS is a networking method that permits the linking of constructive simulations (digital computer models), virtual simulations (man-in-the-loop or hardware-in-the-loop simulators), and live players located at distributed locations into a single environment/scenario. Such linking can result in a more realistic, safer, and/or more detailed evaluation of the system under test.

2.0 General Challenges for the Program Manager

A program manager considering the use of distributed simulation or distributed testing to overcome test limitations will be faced with two general challenges throughout the test planning and implementation process. The first is cultural bias within the acquisition and test and evaluation communities; the second is the lack of experience with distributed testing technology within the communities. The program manager must be aware of these challenges and be prepared to mitigate the impact of these on test planning.

Cultural bias manifests itself in several ways to impact the decisions made in the test planning and implementation process. While these biases may not be explicitly stated, they will often be the basis behind the input and advice the program manager receives from the test and evaluation community.

- Traditional test methodologies are adequate. Processes and methodologies for testing specific types of systems have been developed and institutionalized over decades and through the testing of multiple systems. These processes tend to be sequential in nature and based on the maturity of the system under test and the capabilities of the ranges/facilities. The range/facility engineers and the system/test engineers have accepted these processes and their inherent limitations for so long that they have problems conceiving of different ways to test a system. The challenge will be to get the test and evaluation community to accept the need to develop new processes and technologies to overcome test limitations.

- All testing must be conducted using native spectrum. This is a bias particular to those systems that interact with both friendly or threat systems using radio frequency, infrared, or other spectra. Since the technologies for distributing testing or distributed simulation typically link facilities using digital transmission, these interactions will have to be converted into a digital format prior to transmission. The challenge will be to convert the native spectrum in such a way as to avoid unacceptable degradation of signal and to gain acceptance from the traditional test community that the interactions remain valid.

- We can meet your test requirements at our facility/range. The test and evaluation infrastructure of the Department of Defense (DoD) has been developed over decades by the services to test specific systems. Since the mid-1980s, the defense drawdown and budget cuts have resulted in considerable reduction of facilities and ranges, primarily to reduce perceived duplication of capability between the services. As a result, test facilities and ranges are reluctant to admit any limitations in their capabilities to meet test requirements. Additionally, the competition among ranges/facilities for business has resulted in thinly veiled animosity among the range/facilities and only minimal cooperation. Finally, the services, to protect their remaining test resources, have established policies and processes that make it difficult for an acquisition program to conduct testing at another service's range or facility. All of these combine to work against a program manager attempting to overcome test limitations through the linking of test facilities.

Distributed testing and distributed simulation have actually been used within the test and evaluation communities for many years. All system integration laboratories, hardware-in-the-loop facilities, installed systems test facilities, and even open air ranges conduct distributed testing as a normal process and usually incorporate a level of distributed simulation within their test environments. Some of these facilities have established elaborate networks to link various laboratories and facilities at a single installation into combined test environments. However, very few of these facilities have accepted that the methodologies they use within their facilities are distributed testing and distributed simulation and can be extended to link to other facilities. This lack of acceptance may be due to a lack of experience at the facilities and ranges and a tradition of bottom-up planning of tests based on the specific capabilities of a specific laboratory, test facility, or range. The development of a distributed test environment requires the combination of system under test, facility, range, network, instrumentation, and analysis functions lead by a strong systems engineering function focused on providing the best test environment for the system under test (SUT). This process is inherently a top-down process driven by the operational requirements of the system rather than existing test capabilities. JADS has seen little evidence of test organizations establishing processes that will support planning and implementation of distributed test environments. The program manager will have to take the lead to develop the experience base to navigate through the planning and implementation of a distributed test.

3.0 ADS-Inclusive Test Concept Development Methodology

The methodology described in the JADS report, *A Test Planning Methodology -- From Concept Development Through Test Execution,* used an example which was couched in terms of OT&E. But, as pointed out in the report, as OT&E moves left on the acquisition timeline and as new systems demand ever more complex test environments, the process is applicable to DT&E as well.

The methodology makes an *assumption that ADS can technically support representation of the military operating environment at the campaign or theater level. If ADS is included in the test planning tool kit from the outset, it is possible to begin the test concept development process at the top rather than the bottom. (The "top" may not be at theater level; it is established by the relevant operational task or tasks.) The methodology described in this paper is a top-level methodology. It is an approach which is compatible with the "strategy to task" or "mission-level evaluation" philosophy. It is also a methodology for test concept development which incorporates the consideration of ADS -- it is not an ADS planning methodology. This methodology is designed to provide insights on whether to use ADS and where in a test program the use might fit.*

The advantage of a top-down approach to test concept development is that the whole gamut of interactions is available for consideration even if many of those interactions are assessed as irrelevant and excluded from the final concept.[4] *The top-down approach doesn't require that every possible interaction be included in the test, but it does require an item by item assessment of each interaction. Decisions to exclude interactions are conscious decisions not default decisions as a function of a bottom-up approach.*

Mission- or task-level evaluation is explicitly a top-down approach. The top level, for test planning purposes, may be much lower than campaign or theater. Just how high the top level is, is a function of the task being evaluated. Some systems may have little or no interaction beyond a unit boundary, and others may interact closely with the theater and campaign levels. In the case of DT&E, it is necessary to substitute "specification sets" for "tasks." The substitution should not be difficult. While there may be evolutionary changes as a program evolves, the operational tasks expected of a new system are known as a result of mission needs analysis and serve as the basis for initial requirements development. It shouldn't be hard to map certain system specifications to a specific task. The methodology, as described, should be useful for most DT&E.

Given that the methodology applies to both DT&E and OT&E, and that the trend in T&E is to consolidate DT&E and OT&E whenever possible, it follows that the most appropriate application of the methodology is to an entire program, from concept exploration to production, deployment, and operations support. Although the methodology could be applied to a single acquisition phase

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[4] A top-down approach will not help if it is implemented with a mind set fixed on historical limitations. It's necessary for the test planners to understand that ADS provides opportunities which weren't previously feasible.

or even to a single test, this paper will focus on the development of a test plan that spans the life of a program.

The logic flow for the initial elements of the concept development methodology is shown in Figure 1.

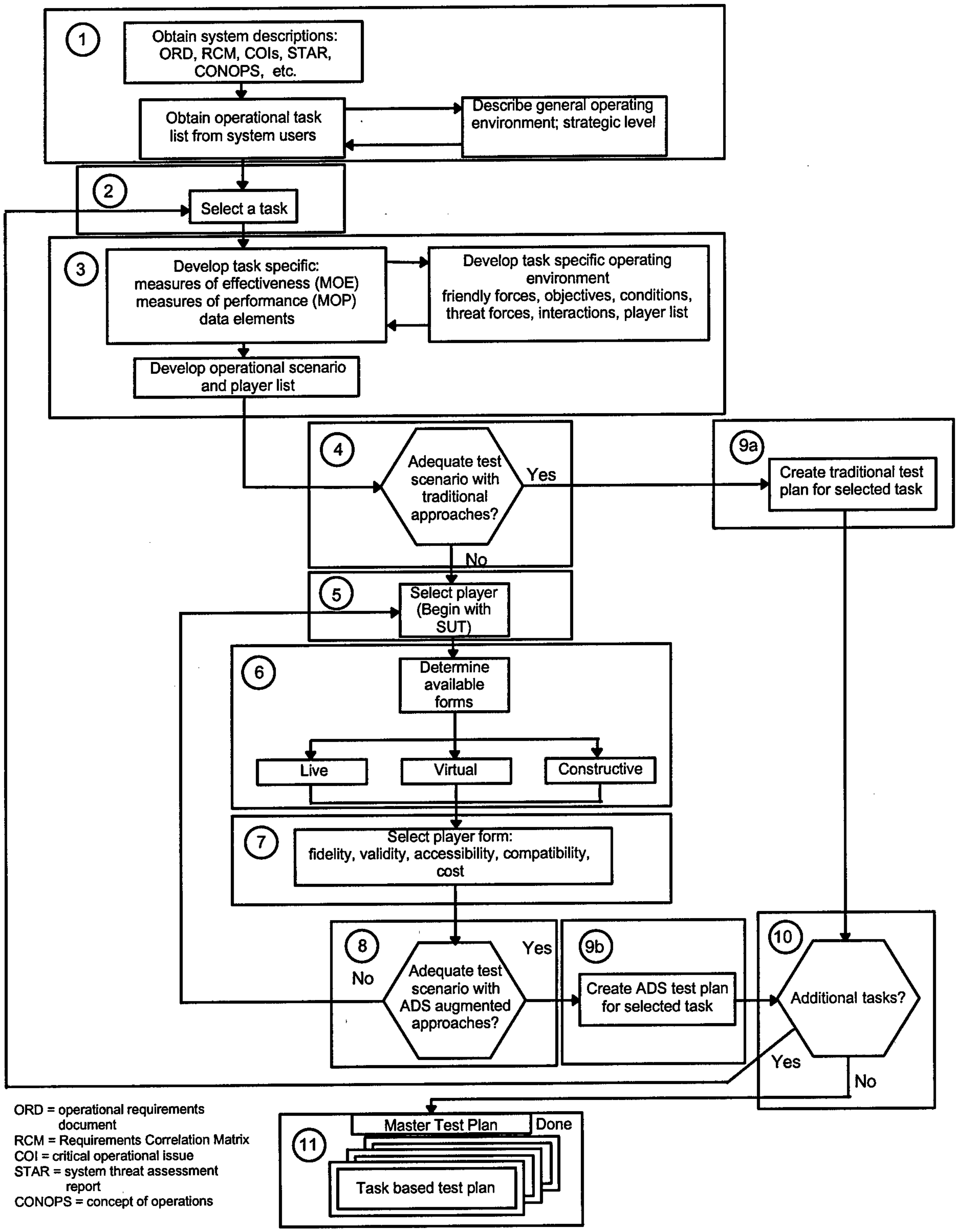


Figure 1. Logic Flow for Initial Elements of the Planning Methodology

Although the test concept development process is presented in a sequential format and flow, the actual implementation of the process will likely be conducted in a parallel fashion. The degree of parallelism will be driven by the available resources and the experience level of the concept development team. The program/test manager will have to carefully control the process to insure each task is carefully examined and the appropriate test concept developed.

3.1 Step 1. Understanding the System Under Test

Step 1 requires the test planners to research the acquisition documentation to gain a thorough understanding of the SUT and its intended operating environment. This understanding incorporates the operational tasks the system is designed to perform, the critical system parameters, the system and operational requirements, the concept of operations, the logistical support concept, and the top level or general operating environment. One piece of the understanding deals with the technical or specification aspects of the system. The other piece deals with the interactions between the technical characteristics of the system and the world it operates in from a strategic perspective --- the friendly and supporting forces, the natural environment, and the threats posed by the enemy.

The task of understanding the SUT presents the first challenge to the program or test manager. The level of documentation available during the concept exploration or program definition and risk reduction phases of a new program is typically limited to a mission needs statement and possibly a draft of the operational requirements document. These documents may not adequately describe the operational tasks, the concept of operations, or the operating environment. The program manager will need the support of the requiring operational commands, both within the service(s) and within the unified command structure, to help define the operating environment and the interactions expected of the system. Additionally, since it is likely the operating environment will include other new or upgraded systems, the program manager will be required to interact with other programs to understand the capabilities and interactions required by these systems.

3.2 Step 2. Select a Task

This step involves the selection of a specific task. A complex system may be assigned many operational tasks. Some tasks may be very similar, while others may be vastly different. It is possible that similar tasks may be grouped for evaluation purposes and tested on the basis of a single task.

Even though the program and test manager may have carefully worked through Step 1 and believe they understand the system under test, they cannot proceed through the planning process in a vacuum. The planning process must be conducted with both developmental and operational testers and will probably require support from the requiring commands. The manager must carefully coordinate and control this process to ensure a top-down process uninhibited by historical limitations, cultural bias, or hidden agendas.

3.3 Step 3. Develop Relevant Measures

Once a specific task is selected, the planners can develop relevant measures for the task and a task-specific operating environment. The operating environment in combination with assigned objectives and missions provides a context for the test measures and defines the cast of players. In order to structure a test, the player cast has to be embedded in a dynamic operational scenario. The scenario supports detailed mission layout activities and time-sequenced events for the SUT. The scenario developed in Step 3 is an operational scenario; a real world scenario -- not a test scenario.

In this step, the challenge to the manager is to control his planning team and to produce a real world operational scenarios. Experienced test managers and engineers involved in the planning will be aware of the potential limitations of the various ranges and facilities. The temptation will be to narrow the scenario toward the known test capabilities. A potential solution to this challenge is to allow only the operational representatives to actively participate in this step. This would allow the testers to better understand the operational scenario while avoiding potential narrowing of the scenario.

3.4 Step 4. Consider Using ADS

The activity described to this point is simply a test planning or test concept development approach. Step 4 is a switch point -- to include or not to include a detailed consideration of ADS use as part of the concept development methodology.

At this time the test planners will move from the real-world operational scenario to a series of test scenarios. Each test scenario will have certain assumptions concerning the test objectives appropriate for a particular phase of the development. For example, in the program definition and risk reduction phase, the planners will develop scenarios to examine the trade space for the program. Later, in the engineering and manufacturing development phase a similar test scenario will be used to evaluate the actual performance of components and eventually the SUT. For each phase of testing, the program manager must lead the T&E representatives to determine if an adequate test environment can be represented using traditional test resources. If the task can be adequately and affordably represented and the measures evaluated, then traditional resources and methodology may be the preferred approach. However, if the test planners are reasonably certain the test environment cannot be adequately represented using the traditional test approaches, then they have two choices: accept the test limitations or explore ADS to see if the technology can make a better test within the fiscal constraints. This phase may require representatives of the appropriate test ranges and facilities to join the test planning team.

Stated succinctly, the decision associated with Step 4 is about the adequacy of the test scenario as compared with the operational scenario. In a world with no fiscal or safety constraints, the operational scenario and the test scenario would be identical. In the real world, the issue becomes "can we approximate reality with sufficient accuracy to have a satisfactory test." If the test planners cannot provide an appropriate test environment using traditional test approaches,

then the answer is "no," and the planners should explore whether ADS can do anything to improve the situation. If the answer is "no," then the process moves along to step 5. If the answer is "yes, we can provide a suitable test environment," then the planners can proceed with a traditional test plan for <u>*that particular*</u> *operational task. Other tasks may require different approaches.*

3.5 Step 5. Select a Player

Traditional testing shortfalls often include an insufficient number of test articles, insufficient number of threats, and inadequate representation of friendly force interactions. The process of ADS exploration begins with a visit to the player list developed in Step 3, and the first player on that list is the SUT. Depending on where the program is, the SUT may be available in a variety of forms. Early in the program, the SUT may only be available as a digital system model (DSM). Later the SUT may exist in brassboard form with a variety of subcomponents scattered among a variety of vendors. Eventually the SUT will be available in prototype or production version form, and a training simulator version will emerge. (The DSM version is still available at this stage.)

At each stage of the program, the challenge for the program manager and test planners is to select the appropriate representation of the SUT. This selection will normally be biased toward the most current, highest fidelity representation, however, a lower fidelity version could be selected based on the test objectives required to test a particular operational task. Early in a program, the DSM version of the SUT will exhibit the performance identified in the specifications or may have the ability to support trade-offs of performance values. Since the performance of a DSM SUT is fixed, this version is not appropriate for evaluating actual performance. However, such a representation is appropriate for answering questions concerning the impact a given level of performance has on the operational scenario. Later in the program, performance measurements will be made using brassboard prototypes, but it may be more cost effective to update the DSM to measured performance and use it for some operational evaluations. Similar decisions will be made for each representation of the SUT developed during the life of the program. For some test scenarios, two different representations of the SUT having the same performance characteristics, e.g., a DSM and a brassboard, may be used to represent a certain concepts of operations. The selection of SUT representation with its associated fidelity for each test scenario is the driver for the next step in the process -- selecting other players.

3.6 Step 6. Determine Player Representation

The determination of a player representation will be made based on both the availability of representations and the test objectives. This step addresses both of these criteria. The planning team will need to investigate the available representations for each player beginning with the SUT. The planning team will also have to define the requirements for the test to meet the test objective. After looking at the SUT configuration choices, the planners can move on to the other players. If the player list is prioritized on the basis of the more direct interactions, then the more important players are addressed first. For each player, the test planners must have access to

information about the various manifestations of the player. They must know what forms are available, and they must learn what they can about capabilities and costs for each form.

Step 6 involves a lot of research and learning.

Representations of the major players will not be limited to the various test ranges and facilities. The program manager and planners will have to investigate a wide variety of facilities to find the appropriate representations. Research laboratories and battle laboratories represent two classes of facilities that provide a rich source of capabilities with varying fidelity for the test planner. The modeling and simulation agencies are also sources for information concerning various representations. Both the Defense Modeling and Simulation Organization (DMSO) and the service agencies have developed modeling and simulation resource repositories (MSRR) to store and maintain information about various representations and about previous environments using these capabilities. Another source to investigate is the training community for the particular player. Finally, the opportunity may exist to connect with live players. The emphasis of the research should be to find all the representations rather than settling for what the test ranges and facilities have available.

The program manager will not only have to find the various representations, but will also have to determine what capabilities and fidelity each representation can bring to his event. Considering that most facilities operate on some sort of fee for service arrangement, it is often a challenge for the program manager to get by the marketing and gain complete understanding of a particular facility's actual capabilities and fidelity.

The level of research involved in this step may require the program manager to implement a level of parallelism in the process. While research is being conducted, the existence of a player can be assumed and the team can skip to Step 8, continuing the iteration until an initially adequate environment is developed. Additionally, other tasks can be examined in parallel with the initial outputs being fed into the research process in Step 6. Finally, the team will return to completing Steps 6 through 8 for each player and each task.

3.7 Step 7. Fidelity Versus Cost

Step 7 involves the art of compromise between fidelity and cost. With the information gleaned in Step 6, the test planners are in a position to make reasoned choices about the players in the test and the appropriate form of representation for each of them. Rough order of magnitude (ROM) costs are adequate in the test concept development process. Costs are refined in detailed test planning.

The program manager is limited in this step by the ability to get accurate information in Step 6. The challenge for this step is to accept the limitations and attempt to identify the level of fidelity required and the levels of fidelity available. The purpose is to develop a test concept. During detailed planning, all these initial compromises will be revisited and better information may lead to different answers. A subtle point to remember is that fidelity and cost are not always directly

related. For example, a hardware-/man-in-the-loop laboratory may prove to be more expensive to operate than a live system depending on how the live system is connected.

3.8 Step 8. Evaluate Adequacy of the Environment

When the process reaches Step 8, the question facing the planners involves the adequacy of the environment which will be created by the interactions of the players selected. Each time Steps 5 through 7 are executed, the planners must ask whether more players are needed. If so, they return to Step 5. Step 5 is executed repeatedly until the test planners are satisfied that the test environment is rich enough in terms of meaningful interactions to support a sound test.

Once the initial test environment is defined, the test planners should review the fidelity choices and evaluate the interactions between each of the players. The iteration of steps 5 through 7 will define a set of players based on the fidelity required from each player by the SUT. However, most operational tasks will also require some or all the players to interface in some form with one another. The challenge is to ensure that all the interactions among all the players are meaningful with respect to the objectives of the test.

3.9 Step 9. Initial Planning

When the test planners are satisfied with the test concept for a given operational task, they can proceed with initial test planning for the associated test.

Initial test planning is conducted to the level necessary to support the requirements of the master test plan to be developed in Step 11. For an acquisition program, the master test plan will be the test and evaluation master plan developed according to the requirements in DoD Regulation 5000.2-R, *Mandatory Procedures for Major Defense Acquisition Programs (MDAPS) and Major Automated Information System (MAIS) Acquisition Programs,* Appendix III.

3.10 Step 10. Additional Tasks

Step 10 involves the examination of the functionalities of the SUT, and the assessment of the necessity for further testing for additional operational tasks. If there are additional operational tasks that differ enough from those already addressed in test planning to this point, then the planners need to loop back to Step 2 of this process and develop another test concept. Planning cannot move on to Step 11 until initial planning has been completed for all operational tasks.

Step 10 can be performed sequentially after each iteration of Step 9 is completed, or if there are enough planning resources, planning for additional tasks can go on in parallel. In any case, test planning is not complete until all the relevant operational tasks have been addressed.

3.11 Step 11. Develop Master Plan

The task associated with Step 11 involves the deconfliction and coordination of each of the individual task-oriented test segments. Essentially Step 11 involves the development of the master plan and schedule.

The most challenging aspect of this step is the coordination of individual task-oriented test segments. The test planners need to develop a process to compare the test segments against one another to determine where a single environment may be suitable for evaluating multiple tasks. This comparison may involve adding players to one or more environments to establish the superset required for multiple tasks.

Since the master plan covers the entire life of the program, another aspect of coordination and scheduling that should be considered is the evolutionary aspects of the environment(s). The program manager should plan to evolve simple environments used early in a program into the more complex environments used for later test events. Just as the program manager develops a risk management approach for the development of the system, so should a risk management approach for the development of the test environment be developed. Finally, the program manager should consider the ability to transition portions of the test environment to the training system.

4.0 ADS-Based Test Planning and Implementation Methodology

Assuming the decision is made to implement ADS-based testing, the following methodology applies. This methodology follows the steps given in the high level architecture (HLA) federation development and execution process (FEDEP) model [Ref. 1]. In comparing these guidelines with the FEDEP model, note that the terms "ADS architecture" and "distributed test" used here equate to the term "federation" in the FEDEP model, and the terms "facilities," "participants," and "players" used here equate to the term "federates" in the FEDEP model.

The FEDEP model groups the activities needed to develop and execute a distributed test into six steps.

- *Step 1: The test sponsor or evaluator and the distributed test development team define and agree on a set of objectives and document what must be accomplished to achieve those objectives. This is a test planning step and is addressed by the test planning methodology.*

- *Step 2: A representation of the real world domain of interest is developed and described in terms of a set of required objects and interactions. Most of the activities under this step are addressed by the test planning methodology.*

- *Step 3: Distributed test participants (federates) are determined, and required functionalities are allocated to the participants.*

- *Step 4: The federation object model (FOM) is developed (if HLA is implemented), participant agreements on consistent databases/algorithms are established, and modifications to federates are implemented (as required).*

- *Step 5: All necessary distributed test implementation activities are performed, and testing is conducted to ensure interoperability requirements are being met.*

- *Step 6: The distributed test is executed, outputs are generated, and results provided.*

The FEDEP model breaks the six steps into activities, as shown in Table 1.

Table 1. Distributed Test Planning and Implementation Activities

STEP	*ACTIVITIES*
1. Define Distributed Test Objectives	*1.1 Identify Needs* *1.2 Develop Objectives*
2. Develop Conceptual Model	*2.1 Develop Scenario* *2.2 Perform Conceptual Analysis* *2.3 Develop Test Requirements*
3. Design Distributed Test	*3.1 Select Participants* *3.2 Allocate Functionality* *3.3 Prepare Plan*
4. Develop Distributed Test	*4.1 Develop FOM* *4.2 Establish Participant Agreements* *4.3 Implement Participant Modifications*
5. Integrate and Test Architecture	*5.1 Plan Execution* *5.2 Integrate and Test ADS Architecture*
6. Execute Distributed Test and Analyze Results	*6.1 Execute Distributed Test* *6.2 Process Output* *6.3 Prepare Results*

Although the FEDEP and the distributed test planning and execution guidelines presented in this report and its companion report are presented in sequential step format, the program/test manager must accept that the actual process is a system engineering process with the associated iteration between steps. Additionally, JADS' experience demonstrates a considerable amount of parallelism during steps 1 through 3 and again during steps 3 through 5. JADS recommends the development of a detailed project schedule to manage these activities.

4.1 Step 1. Define Distributed Test Objectives

According to the FEDEP model, the purpose of the activities for this step is to define and document a set of needs that are to be addressed through the development and execution of a distributed test and to transform these needs into a more detailed list of specific test objectives. The key activities for this step and the activity inputs and outputs are shown in Figure 2.

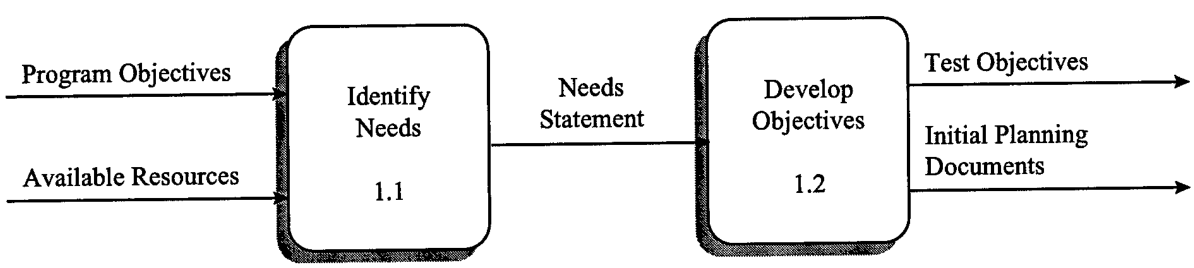


Figure 2. Define Distributed Test Objectives

At the beginning of this process, the program manager needs to evolve the test concept planners into the integrated product team (IPT) that will conduct the detailed planning and implementation of the distributed test. Every organization directly involved in the distributed test should be represented on the team. The members on the team must have the authority to speak for their organizations and must have the ability to bring the appropriate experts from their organizations to provide input to the IPT. JADS' experience identifies two key members of the IPT. The chairman of the IPT must have the authority to make all decisions relating to the test content, schedule, and resources. The chairman's primary assistant is the system integrator, the lead technical person responsible for the integration of the various organizations/facilities involved. Given the overall concept is a distributed test environment that spans multiple phases of a program, the program manager must exercise great care in selecting the IPT leadership and membership and nurturing the team throughout its existence.

The program manager should also consider the various uses of the environment over the life of a system and ensure the IPT has representatives from each of the user groups. For example, if the environment will be used for requirements development and engineering trade studies early in the program, the IPT will require representatives from the operational and engineering communities in addition to the test community. Likewise, if there is a potential to evolve the parts or all the distributed test environment into a distributed training environment, the training community will also need to be on the IPT.

4.1.1 Activity 1.1 - Identify Needs

According to the FEDEP model, the primary purpose of this activity is to develop a clear understanding of the problem to be addressed by the distributed test. Inputs to this activity are the program objectives and information on resources available to support a distributed test. The main output of this activity is a needs statement which includes the following.

- *High-level descriptions of critical systems of interest*
- *Coarse indications of fidelity and required behaviors for simulated players*
- *Key events that must be represented in the distributed test scenario*
- *Output data requirements*
- *Resources that will be available to support the distributed test (e.g., funding, personnel, tools, facilities)*
- *Any known constraints which may affect how the distributed test is developed (e.g., due dates, security requirements)*

Although the test concept development phase examined each of these areas in some level of detail, the IPT should carefully review and validate the test concept prior to proceeding into detailed planning. Since the IPT has been expanded to include all the affected organizations, this will ensure the assumptions made during test concept development are valid and confirm the information used to make decisions.

4.1.2 Activity 1.2 - Develop Objectives

According to the FEDEP model, the purpose of this activity is to refine the needs statement into a more detailed set of specific objectives for the distributed test. This activity requires close collaboration between the distributed test user/sponsor and the test development team to ensure that the resulting objectives meet the stated needs. The user/sponsor must clearly define, communicate, and document test requirements early in the test planning phase. The main input to this activity is the needs statement from the previous activity. The main outputs of this activity are a statement of the test objectives and initial planning documents. The test objectives statement should include the following information.

- *A prioritized list of measurable test objectives*
- *A high-level description of key ADS architecture characteristics (e.g., repeatability, portability, time management approach)*
- *Needed equipment, facilities, and data*
- *Operational context constraints or preferences, including friendly/threat/civilian order of battle, geographic regions, environmental conditions, and tactics*
- *Identification of security position, including estimated security level and possible designated approval authority*
- *A configuration management approach*
- *Identification of tools to support scenario development, conceptual analysis, verification, validation and accreditation (VV&A) and test activities, and configuration management*

4.2 Step 2. Develop Conceptual Model

According to the FEDEP model, the purpose of this step is to develop an appropriate representation of the real-world domain that applies to the distributed test environment and to develop the test scenario. During this step, test objectives are transformed into a set of specific requirements for use as success criteria during ADS architecture testing. The key activities for this step and the activity inputs and outputs are shown in Figure 3.

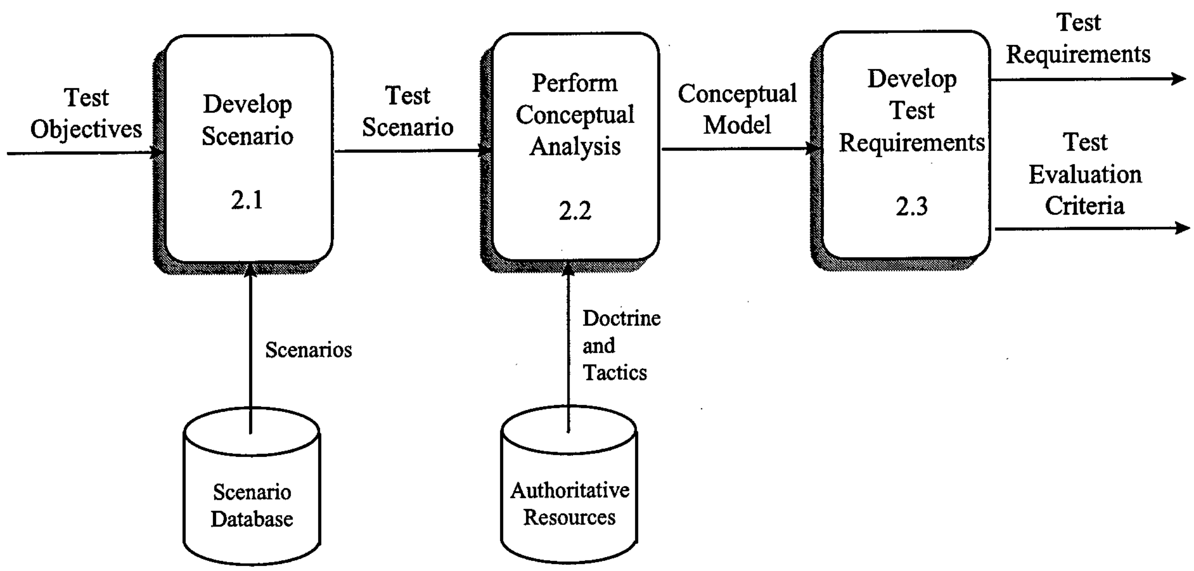


Figure 3. Develop Conceptual Model

4.2.1 Activity 2.1 - Develop Scenario

According to the FEDEP model, the purpose of this activity is to develop a functional specification of the test scenario. The primary input to this activity is the operational context constraints specified in the test objectives statement, although existing scenario databases may also provide a reusable starting point for scenario development. The primary output is the test scenario. The scenario description should include the following.

- *The types and numbers of major players that must be represented in the distributed test*
- *A functional description of the capabilities, behavior, and relationships among these major players over time*
- *A specification of relevant environmental conditions that impact or are impacted by players in the distributed test*
- *Initial/terminal conditions and the specific map projection chosen for the scenario*

Note that most of these items should have been determined/developed during application of the test concept development methodology. However, their determination/development should be repeated here to check/validate the earlier findings.

It is critically important that the "scenario" be approved by an appropriate authority. Ideally, the selected scenario will have been previously developed and approved for other purposes, e.g., developing defense planning guidance. However, even with an approved scenario, the program manager will have to ensure it meets the requirements for the test. For example, the scenario used in the JADS End-to-End Test had previous approval by the U.S. Army Training and Doctrine Command for use in Army OT&E. When JADS evaluated the scenario for use with Joint Surveillance Target Attack Radar System (Joint STARS), we determined the order of battle and movements failed to model rear area activities, e.g., logistics, at the appropriate level of fidelity

for our test. JADS worked with the U.S. Army Test and Experimentation Command to expand the scenario to include appropriate rear area movements and actions. Additionally, the expanded scenario was then run through another model to produce the appropriate intelligence reports for the movements. Not only was the resulting scenario used for the JADS test, but it is also being used for follow-on testing within both the Army and Air Force.

4.2.2 Activity 2.2 - Perform Conceptual Analysis

According to the FEDEP model, the purpose of this activity is to produce a conceptual model of the ADS environment. The primary inputs to this activity are the test scenario from the previous activity, the test objectives statement, and any doctrine and tactics appropriate for the scenario. The output of this activity is the conceptual model which provides an implementation-independent representation that serves as a vehicle for transforming objectives into functional and behavioral capabilities, and provides a crucial traceability link between the test objectives and the design implementation. The conceptual model is a description of the players, their actions, and any interactions among players that need to be included in the distributed test in order to achieve all test objectives. These are described without any reference to specific simulations that will be used.

The primary challenge to the IPT for this activity is to develop a conceptual model which is actually implementation independent. As discussed previously, the IPT is made up of experienced testers and of representatives from the appropriate ranges and facilities. Each of these brings with them a database of capabilities which is likely to impact the conceptual model. At this stage, the conceptual model should not be limited by the capabilities of a specific range, facility, or simulation. It should accurately reflect the test objectives and appropriate doctrine and tactics.

4.2.3 Activity 2.3 - Develop Test Requirements

According to the FEDEP model, the conceptual model will lead to the definition of detailed distributed test requirements and test evaluation criteria. These requirements should be based on the distributed test objectives, should be directly testable, and should provide the implementation-level guidance needed to design and develop the distributed test (cost impact factor of rank #9 - see Appendix A). The test requirements will also be the basis for the criteria for evaluating test results (see Fig. 3). Major top-level requirements which should be addressed include the following (although some of these requirements should have been developed during application of the test planning methodology, their development should be repeated here to check/validate the earlier findings).

- *Fidelity requirements*
  - *The fidelity requirements for all players represented in the distributed test scenarios must be determined. The required fidelity depends upon the maturity of the SUT, the SUT test objectives, and the nature of the interactions between the SUT and the other players.*
  - *The fidelity of the SUT representation may be limited to available models or test articles. For example, during early developmental test and evaluation (DT&E), a low-fidelity*

digital model may be the only SUT representation available, but during late DT&E and OT&E, possible SUT representations may include high-fidelity digital models, hardware-in-the-loop (HWIL) labs, and live test articles. If multiple SUT representations are available with varying levels of fidelity, the choice will usually be driven by the SUT test objectives and other considerations such as availability and cost.

  - *The required fidelity for the other players normally depends on the fidelity of the SUT, the sensitivity of test objectives/measures to player interactions with the SUT, the strength of the interactions with the SUT (players that have strong, or tightly coupled, interactions with the SUT will generally have higher fidelity requirements than those which do not), the test objectives, and cost and availability considerations.*
  - *It is important to involve SUT experts from the beginning of the distributed test program in order to determine fidelity requirements, establish the data and instrumentation requirements, verify/validate the analytical approach, assist in the development of test matrices and test procedures, and provide overall SUT expertise. The support of more than one SUT expert should be planned for (and budgeted for) throughout the test.*

- *Interaction requirements*
  - *Use the conceptual model to determine the data types that must be exchanged among players to permit interaction including entity state data, tactical messages, launch and detonation indications (if appropriate), and trial start and stop notification.*
- *Latency requirements (cost impact factor of rank #4 - see Appendix A)*
  - *Determine the maximum acceptable latency and latency variations for each pair of interacting players. The maximum latency requirement will be determined by how closely coupled the interactions are and by the maximum allowable error in the location of one player as perceived by the other.*

The determination of a latency budget can be one of the more challenging engineering problems for the IPT. The tendency for most engineers is to underestimate the amount of allowable latency for a particular problem. JADS' experience is that the latency budget can usually be larger than originally estimated. Many factors drive the estimate and the IPT must carefully consider every part of the problem. The program manager must ensure the IPT carefully develops these requirements.

- *Data reliability requirements*
  - *Determine the maximum acceptable level of ADS-induced errors, such as dropout rate and out-of-order data messages. The allowable errors may vary with data types. For example, some loss of entity state data may be tolerable for short durations if dead reckoning can supply the missing data within acceptable error tolerances. However, the loss of a single discrete message may invalidate an entire trial. This determination may drive the reliability requirement for data transport and guide the selection of data transport protocols.*

- *Data analysis requirements*
  - *Draft a preliminary data management and analysis plan (DMAP) that details the analysis approach for each test objective. From the DMAP determine which data must be collected and the analysis techniques to be applied.*

One of the key findings from the JADS' experiences is that data collection and analysis in a distributed environment can be very different from conventional test methods. Distributed testing will typically produce considerably more data per unit of time than live testing. Add this to the availability of more interacting units per segment of time and the data collection or data analysis process can be overcome with data. Finally, consider that laboratories typically have more opportunities to instrument systems than when the systems are operated in a live mode. This potential problem needs to be considered when evaluating analysis techniques and tools.

After all these requirements have been developed, the capability of the support agencies (e.g., simulation or range facilities, networking and engineering team) to support the test must be clearly stated and documented, such as by a statement of capability (SOC). The SOC documents the set of requirements and provides a clear statement of the support agency's capabilities, constraints, and limitations in meeting those requirements.

A key challenge for the IPT during this phase will be to provide requirements to the supporting organizations in a consistent format. The Major Range and Test Facility Base has developed a universal standard that allows for submission of the requirements to the range/facility in the form of a program introduction document (PID). Unfortunately, other training and laboratory facilities have not adopted this standard and the use of the standard throughout the test community is not consistent. JADS recommends that the IPT adopts a standard practice which will be used for all the facilities and organizations. The PID format should be adequate for the IPT to document the requirements for each of the facilities in the distributed environment.

The SOC mentioned above is the corresponding document to the PID. In this case, the supporting organization describes its understanding of the requirements and its capabilities to meet the requirements. If upgrades or modifications are required to the facility, the SOC should provide a detailed understanding of the scope of the changes and the resources and schedule required. For facilities not familiar with these documents, the program manager may be required to lead the organization into providing adequate information.

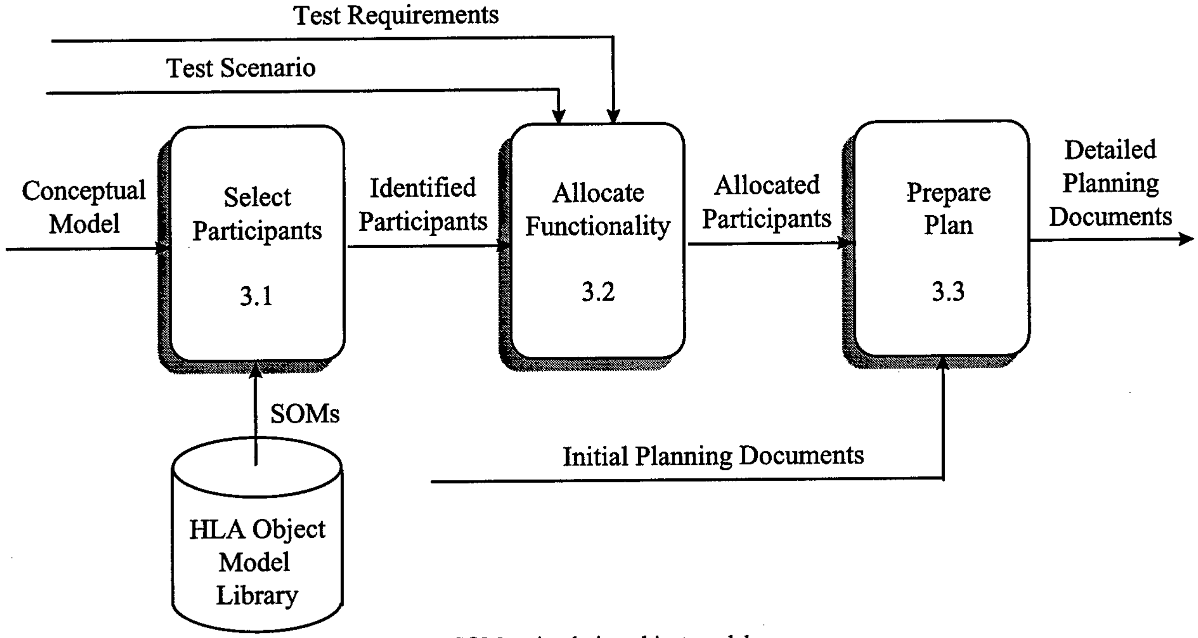
The support agencies also need to create an integrated, detailed work breakdown structure (WBS) early in the program which is consistent with the SOC. It is also important to have accurate cost estimates allocated against the WBS tasks in order to help make program management decisions.

This requirement will place a challenge on the supporting facilities. Many of the available facilities are not familiar with developing work breakdown structures to be used to estimate the resources required and to track the development of the environment. Another problem will be the ability to provide an estimate with the appropriate level of fidelity. For example, the normal

practice for a particular test facility is to estimate costs based on a week of testing. This is based on years of experience at the facility. However, when such a facility is integrated into a distributed environment, it may be more appropriate to estimate costs based on hourly or daily usage, especially during integration testing.

4.3 Step 3. Design Distributed Test

According to the FEDEP model, the purpose of this step is to identify, evaluate, and select all distributed test participants (federates), allocate required functionality to those participants, and develop a detailed plan for test bed development and implementation. The key activities for this step and the activity inputs and outputs are shown in Figure 4.



SOM = simulation object model

Figure 4. Design Distributed Test

4.3.1 Activity 3.1 - Select Participants

According to the FEDEP model, the purpose of this activity is to determine the suitability of individual player representations (e.g., simulations, HWIL labs, or live players/ranges) to become participants in the distributed test. The input to this activity is the conceptual model developed in Activity 2.2. The output is an identification of the specific player representations selected.

This activity involves the identification of specific simulations, HWIL labs, or live players/ranges to be used in the distributed test and their locations. This selection is driven primarily by the following factors.

- *Perceived ability of potential representations to represent the players' behavior and the interactions specified in the conceptual model*
- *Fidelity requirements for each player*
- *Managerial constraints, such as availability cost, schedule, and security considerations*
- *Technical constraints, such as VV&A status and portability*
- *For live players, the selection of particular test ranges is also driven by considerations of range instrumentation quality and quantity and data processing capability*

The primary challenge in this step relates to truth in advertising. All test facilities and most other facilities owe their continued existence to their ability to attract customers. As a result, the program manager will have to carefully question each candidate facility to determine both the capabilities and limitations of the facility. At the same time it is also useful to look at other factors which may impact your test event. These factors include previous experience with linking, previous accreditations, instrumentation, time synchronization capability and data collection and analysis capabilities.

4.3.2 Activity 3.2 - Allocate Functionality

According to the FEDEP model, the purpose of this activity is to allocate the responsibility to represent the entities and actions in the conceptual model to the participants. This activity will allow for the assessment of whether the set of selected participants provides the full set of required functionality or whether one or more of the representations will need to be enhanced to meet the distributed test requirements. The inputs to this activity are the identified participants from the previous activity, along with the test requirements, the test scenario, and the conceptual model. The output is allocated requirements for the participants, including any requirements for modifying existing player representations or designing new ones.

Once requirements are allocated and carefully and consistently documented, the program/test manager can enter into formal discussions with the supporting facilities and organizations. It is at this step when the PID is provided to the supporting facility, and the facility then produces a SOC with the associated estimates for necessary modifications. While adding formality to the process will likely require additional schedule, it is important for the program/test manager to understand early in the process the scope of the modifications with the associated risk.

Another issue that must be addressed by the IPT is the tasking of operational units or assets. During the allocation of requirements, some of the players will be live and the program/test manager will have to arrange for this support. Each of the services has different processes by which operational resources can be tasked in support of a test event.

The U.S. Army uses the operational test plan (OTP) and the test requirements council (TRC) to identify, prioritize, and task operational units in support of T&E. Although this process provides a well-defined and structured approach, the program manager and IPT must be careful to identify all the required support, including support for test environment integration and testing prior to the actual test event(s). Another challenge for the program manager is to maintain continued coordination of test requirements and details with the operational unit. Tasking to support a

distributed test will often be viewed as an additional, unfunded requirement on the tasked unit. The program manager can ensure the best support by continually striving to make participation in the test a positive experience for the tasked unit.

The other services have less structured processes for identifying, prioritizing, and tasking operational units to support testing of a system. Although requirements for supporting tests are documented in various program documents, e.g., program management directive or test and evaluation master plan, the program manager or the operational test manager is primarily responsible to establish agreements with major commands for the support of a specific test event. The negotiation and continued care and feeding of these agreements can present a time-consuming challenge to the program manager.

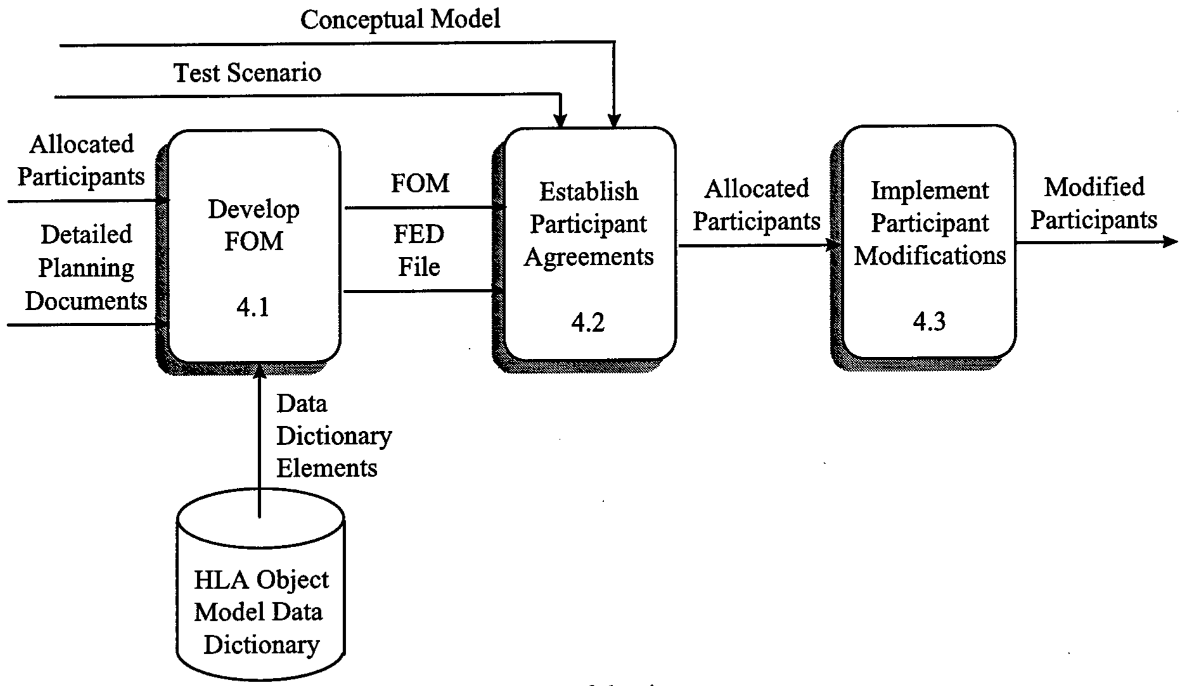
4.3.3 Activity 3.3 - Prepare Plan

According to the FEDEP model, the purpose of this activity is to develop a coordinated plan to guide the development, test, and execution of the distributed test. The inputs to this activity are the initial planning documents prepared during the development of the test objectives (Activity 1.2) and the allocated participant requirements. The output is the detailed planning documents.

An old adage says, "The job is not over until the paperwork is finished." Likewise the planning is not over until the detailed plans are written. Good planning is a task that takes considerable time and effort. The program/test manager's challenge is to find the time and resources to devote to writing the detailed plans. Numerous reasons will be found to avoid this task: "We don't know enough yet." "That is part of our normal process." We can streamline the process if we do not have to develop this plan." Regardless, the process of writing the plan will allow the managers to identify what they do not know, what really is a normal process, and what resources and effort are really required to complete the test.

4.4 Step 4. Develop Distributed Test

According to the FEDEP model, the purpose of this step is to develop the FOM (if HLA is to be implemented), modify the simulations/range facilities if necessary, and prepare the distributed architecture for integration and test. The key activities for this step and the activity inputs and outputs are shown in Figure 5.



FED = federation

Figure 5. Develop Distributed Test

4.4.1 Activity 4.1 - Develop FOM

According to the FEDEP model, the purpose of this activity is to develop the FOM. The inputs to this activity are the detailed planning documents and the allocated participant requirements. The outputs are the FOM and federation execution data (FED) file, if appropriate.

4.4.2 Activity 4.2 - Establish Participant Agreements

According to the FEDEP model, the purpose of this activity is to establish all agreements among participants necessary for a fully consistent, interoperable, distributed simulation environment. The inputs to this activity are the test scenario, the conceptual model, and the FOM (if HLA is to be implemented). The output is revised participant allocated requirements, including any requirements for additional modifications.

During previous steps the IPT has developed detailed plans, completed the PID/SOC process, and developed an interface control document (ICD). Each of these has increased the understanding of how the various facilities and organizations will operate with one another. During this step, the team must arrive at final agreements and issue the appropriate documentation to begin the actual development of the environment. Each of the plans should be coordinated and agreed upon by all the parties. Each organization must agree to operate in accordance with the ICD. Finally, the program/test manager should complete the actual work agreements with each of the supporting facilities and organizations. For facilities that use the PID/SOC process, this may be as simple as agreeing to the SOC and issuing funding. For other organizations, a memorandum of agreement

or understanding may be required, either as a cover document to the PID/SOC or as a complete replacement.

During this activity, the program/test manager may also run into problems related to type or color of money. Acquisition programs are usually funded with research, development, test and evaluation (RDT&E) appropriations. As a result, test facilities and organizations are organized to use these types of appropriations to fund their operations. However, the representations of players in the test may be resident at laboratories, training facilities, and operational units and some of these organizations may require operation and maintenance (O&M) funding rather than RDT&E. The program/test manager needs to ascertain what color of money is required and work with the financial organization to ensure the appropriate funding is available.

4.4.3 Activity 4.3 - Implement Participant Modifications

According to the FEDEP model, the purpose of this activity is to implement participant modifications identified in previous activities. The input to this activity is the updated allocated participant requirements. The output is the modified participants.

4.5 Step 5. Integrate and Test Architecture

According to the FEDEP model, the purpose of this step is to plan the test execution, establish all required interconnectivity between the nodes/players, and test the network prior to execution. The key activities for this step and the activity inputs and outputs are shown in Figure 6.

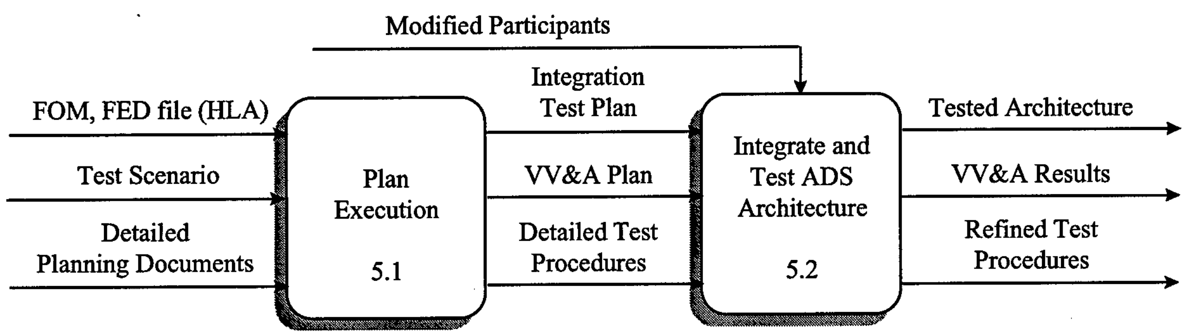


Figure 6. Integrate and Test Architecture

4.5.1 Activity 5.1 - Plan Execution

According to the FEDEP model, the purpose of this activity is to define and develop the full set of information required to support the distributed test execution. The inputs to this activity are the FOM and federation execution data (FED) file, if appropriate, the test scenario, and the detailed planning documents. The outputs are a refined and detailed integration test plan, VV&A plan, and test procedures.

Once all the agreements are signed and all the development schedules are known, the IPT can begin the next level of planning. The integration plan documents a logical build-up of capabilities based on needs and development schedules. Each integration event needs to be carefully planned to accomplish key tasks and reduce risk for the actual tests. Additionally, this activity brings in another group that will almost certainly provide additional challenges for the program/test manager.

The normal security paradigm for certification and accreditation is focused at the facility level. A person or organization within each facility is responsible for documenting and maintaining the security configuration of the facility. This person certifies the configuration to the designated approval authority (DAA) for accreditation of the facility to operate in that configuration. The problems arise when facilities are linked together. Now the accreditation authority for the linked environment is shared between the DAAs of each of the facilities. The challenge for the program/test manager is to get each of the DAAs to agree that the environment provides adequate protection for the data and facilities. JADS developed memoranda of agreement among the various DAAs to obtain this agreement. More recently, DMSO sponsored the development of a security overlay to the FEDEP. This overlay is based on the Department of Defense Information Technology Security Certification and Accreditation Process (DITSCAP) and is applied to the FEDEP. The overlay outlines the steps required during each FEDEP activity which will build up to a joint accreditation of the environment.

4.5.2 Activity 5.2 - Integrate and Test ADS Architecture

This activity combines the separate FEDEP activities of "integrate federation" and "test federation" because of the close connection between the two. An iterative "test-fix-test" approach is recommended, so that the integration and test activities become closely interrelated. According to the FEDEP model, the purpose of these activities is to bring all the distributed test participants into a unifying operating environment and to test that they can all interoperate to the degree required to achieve the test objectives. The inputs to this activity are the detailed integration test plan, VV&A plan, and test procedures. The outputs are refined test procedures (to be used during test execution), VV&A results, and an ADS architecture that has been thoroughly tested and is ready for test execution.

During the integration and test activity the program/test manager faces three related challenges. The first is the challenge of scheduling adequate time for integration and test. We make the basic assumption that most of the facilities used in the test environment are not controlled by the program/test manager. We also make the assumption that the facilities operate under a high percentage of utilization. Given these assumptions, for each integration and test event the program/test manager must work with at least two facilities to coordinate a schedule for the event. This can be very challenging. For example, integration for Phase 3 of the JADS EW Test needed to be conducted between December 1998 and April 1999. JADS required several one- or two-day periods for integration and testing between JADS and the Air Combat Environment Test and Evaluation Facility (ACETEF). Additionally, immediately prior to the actual test, JADS required an additional two to three days of full dress rehearsal with all three facilities on line. During the same period, all the facilities were supporting other tests. Scheduling these activities

took a lot of coordination among the facility managers to ensure the integration and test activities were conducted at the appropriate times. A positive aspect of this problem is that, with the exception of the full dress rehearsals, most integration and test activities do not require complete configurations and may be able to be conducted in parallel with other activities at the facility.

Network scheduling and prioritization may also present a challenge to the program/test manager. Current DoD policy requires networking to be conducted over Defense Information Systems Network (DISN) common-user networks wherever possible. One of these services, the Defense Simulation Internet (DSI), has a scheduling process that allows the user to schedule periods of usage where a certain level of service is provided to the user. This essentially adds another schedule which must be coordinated. Other services are available at all times but may not be able to support the required levels of service. In some cases, e.g., Secret Internet Protocol Router Network (SIPRNET), a user basically takes the chance that performance will be adequate for the test at a scheduled time. Other networks provide scaleable services which adjust based on traffic. The program/test manager must be aware of the type of service that will be provided and allow for any potential impacts in planning. In light of these considerations and the lessor capabilities offered when JADS conducted its planning, the JADS approach was to lease dedicated commercial T-1 communications lines.

Another challenge for the program/test manager and the facility managers is configuration management. Again, because the facilities are shared by many users with different requirements, the program/test manager needs each facility to demonstrate a process to guarantee the facility is configured properly for each integration and test event. Often, facility managers will claim that configuration management is a normal business practice that the program/test manager should just accept. JADS' experience with multiple facilities shows that every facility is likely to have problems returning to a configuration multiple times over a period of time. The cost to the program/test manager may be a wasted integration or test event, one that, due to the scheduling issues discussed above, may have significant impact on the activity.

4.6 Step 6. Execute Distributed Test and Analyze Results

According to the FEDEP model, the purpose of this step is to execute the distributed test, process the output data from the test execution, report results, and archive reusable test products. The key activities for this step and the activity inputs and outputs are shown in Figure 7.

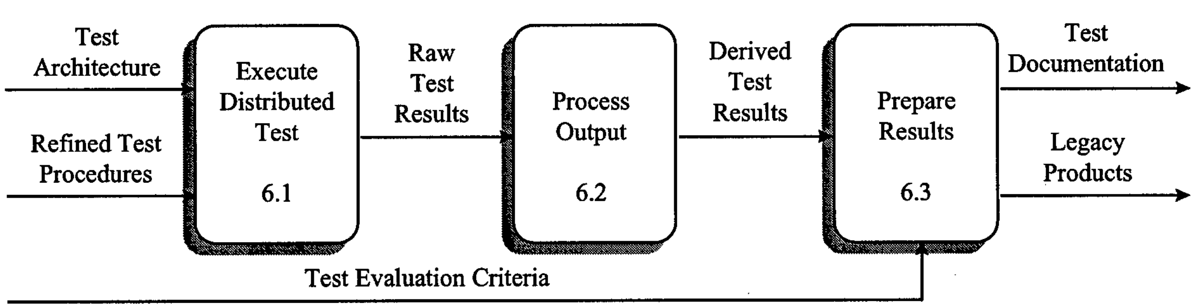


Figure 7. Execute Distributed Test and Analyze Results

4.6.1 Activity 6.1 - Execute Distributed Test

According to the FEDEP model, the purpose of this activity is to exercise all distributed test participants as an integrated whole to generate required outputs and thus achieve the stated test objectives. The inputs for this activity are the refined test procedures and tested ADS architecture from integration testing. The output is the raw test results.

Again, one of the key challenges for the program/test manager during execution is related to scheduling. In the case of execution, the ability of the test manager to manage without the entire environment is denied. Also, depending on a facility configuration, the entire facility may have to be dedicated to the test. In the JADS EW Test example above, the requirement for JADS was for two consecutive weeks of testing to complete the test matrix. A comparison of the ACETEF and Air Force Electronic Warfare Evaluation Simulator (AFEWES) calendars for January through June 1999 yielded only two weeks where JADS could conduct its test. However, the test scheduled immediately prior to the JADS test at ACETEF was the highest priority aircraft program in the Navy, and if they did not complete their planned testing on time, the JADS test would be bumped.

A related challenge for the program/test manager is environment reliability or availability. Test facilities and laboratories are not built with high reliability as a requirement. They do not have redundant systems to bring on line in case of failures. Also, due to the lack of resources to keep up with technology in these facilities, quite often the systems you are using in your environment may be very old. For example, in one facility JADS used, several of the computers supporting the environment were vintage 1970 and 1980 systems. Combining a lack of reliability and the complexity of some distributed environments (one JADS test utilized approximately 85 different computers) results in a high potential for loss of scheduled test time. The program manager must allow for lost test periods when scheduling test execution.

4.6.2 Activity 6.2 - Process Output

According to the FEDEP model, the purpose of this activity is to post-process (as necessary) the output collected during the test execution. The input to this activity is the raw test results from test execution. The output is derived test results.

4.6.3 Activity 6.3 - Prepare Results

According to the FEDEP model, this activity has two purposes: (1) to evaluate the data analysis results in order to determine if all test objectives have been met, and (2) to identify legacy products and make them available to other programs. The input to this activity is the derived test results, along with the test evaluation criteria from Activity 2.3. The outputs are documented test results and legacy products.

5.0 Conclusion

Planning and implementation of a distributed test presents the program/test manager with programmatic as well as technical challenges. A successful program/test manager will be prepared to meet these challenges and produce and implement a plan that will completely test the system and produce adequate insight into the system performance and military worth to justify a production decision.

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7.0 Acronyms and Definitions

ACETEF	Air Combat Environment Test and Evaluation Facility, Patuxent River, Maryland; Navy facility
ADS	advanced distributed simulation
AFEWES	Air Force Electronic Warfare Evaluation Simulator, Fort Worth, Texas; Air Force managed with Lockheed Martin Corporation
C4ISR	command, control, communications, computers, intelligence, surveillance and reconnaissance
COI	critical operational issue
CONOPS	concept of operations
DAA	Designated Approval Authority
DIS	distributed interactive simulation
DISN	Defense Information Systems Network
DITSCAP	Department of Defense Information Technology Security Certification and Accreditation Program
DMAP	data management and analysis plan
DMSO	Defense Modeling and Simulation Organization, Alexandria, Virginia
DoD	Department of Defense
DSI	Defense Simulation Internet
DT&E	developmental test and evaluation
ETE	JADS End-to-End Test
EW	electronic warfare; JADS Electronic Warfare Test
FED	federation
FEDEP	federation development and execution process
FOM	federation object model
HLA	high level architecture
HWIL	hardware-in-the-loop
ICD	interface control document
IPT	integrated product team
JADS	Joint Advanced Distributed Simulation, Albuquerque, New Mexico
Joint STARS	Joint Surveillance Target Attack Radar System
JT&E	joint test and evaluation
JTF	joint test force
MOE	measure of effectiveness
MOP	measure of performance
MSRR	modeling and simulation resource repository
O&M	operation and maintenance
ORD	operational requirements document
OSD	Office of the Secretary of Defense
OT&E	operational test and evaluation
OTP	operational test plan
PID	program introduction document
RCM	requirements correlation matrix

RDT&E	research, development, test and evaluation
ROM	rough order of magnitude
SIPRNET	Secret Internet Protocol Router Network
SIT	JADS System Integration Test; system integration test
SOC	statement of capability
SOM	simulation object model
STAR	system threat assessment report
SUT	system under test
T&E	test and evaluation
TEMP	test and evaluation master plan
TRC	test requirements council
VV&A	verification, validation and accreditation
WBS	work breakdown structure